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Exploring different approaches to improve the inverse problem solutions in electrocardiography

Cardiovascular diseases are the leading cause of death in the EU. It causes 11000 death per day in Europe and 5200 death per day in the EU. Non-invasive techniques that identify patients at risk, provide accurate diagnosis, offer a better understanding of the cardiac electrophysiology and guide therapy still fail. These include electrocardiographic imaging (ECGI), an approach in which inverse methods are used to reconstruct heart electrical activity from potentials measured on the body surface. Despite all the success of ECGI, the understanding and treatment of many cardiac diseases is not feasible yet without an improvement of the solution of its inverse problem.

A homogeneous meshless scheme based on the method of fundamental solution (MFS) was adapted to ECGI. In the MFS, the potentials are expressed as a linear combination of Laplace fundamental solution over a discrete set of virtual point sources placed outside of the domain of interest. This formulation yields to a linear system, which involves contributions of the Dirichlet and the homogenous Neumann conditions (HNCs) at torso surface (or zero-flux) in an equivalent manner. In this work, we first used the singular value analysis and discrete picard condition (DPC) to optimize our setup (in terms of the respective boundary conditions and virtual sources placement) making it less sensible to the regularization chosen. Then, we reconstruct the potentials, by using a new regularization parameter choice method for the MFS ECGI problem based on DPC.

Results demonstrate that: 1. An optimal placement of the sources and/or neglecting the homogeneous Neumann conditions reduces the ill-posedness of the problem, making the solution more robust (less sensible to the regularization chosen). This is especially significant when noise/artifact is present. Furthermore, the computational burden is reduced. 2. The new regularization parameter choice method provided higher correlation coefficients and lower relative errors than the current one in terms of potentials and activation maps, especially for the spiral data. 3. A spatio-temporal solution seems advisable.

To conclude, novel inverse problem methods, some adapted from quite different fields of computer science and mathematics, seems to give a hope to improve the performance of the MFS ECGI solution.